Malaria Detection Using Low-Resolution Microscopes with Deep Learning

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PREDICTING

Motivation: Malaria affects 200 million humans.

What we built

- We observe blood samples using low-resolution microscopes
- We segment red blood cells (RBC) using deep learning
- We use the RBC segmentation to detect malaria parasites.

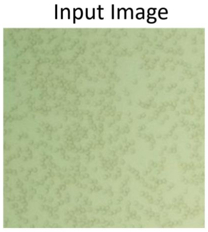
Results

- Red blood cells segmentation achieves a recall of 0.73.
- It improves malaria classification by an order of magnitude: AUC of 99.998%

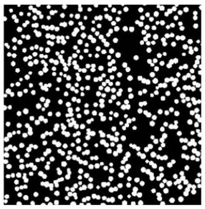
DATA

Red Blood Cell Segmentation

Input Image



Segmentation Mask



820x820x3 cropped to 128x128x3

Labeling: Automatic with Hough Transform, very noisy

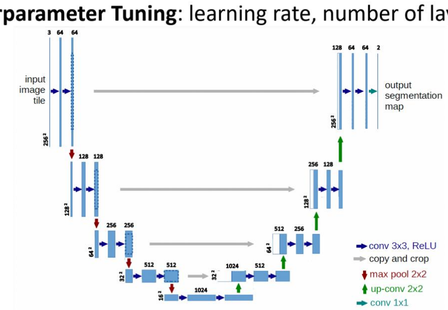
Contribution: Data augmentation on train data to reduce noise in train labels

Splits: 12,000 train / 1,500 val / 1,500 test images

MODELS

Architecture Search: U-Net [1], Fully Convolutional DenseNets [2]

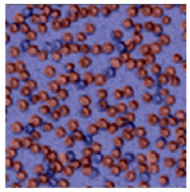
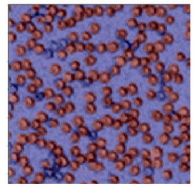
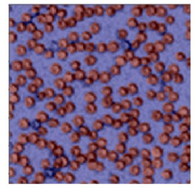
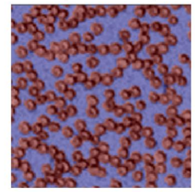
Hyperparameter Tuning: learning rate, number of layers



Contribution: Pixel weights to privilege accurate labels

$$\mathcal{L} = -\sum_{i=1}^{N}\sum_{h=1}^{H}\sum_{w=1}^{W} w_+ Y_{h,w}^{(i)} \log p(Y_{h,w}=1 \mid X^{(i)}) + w_-(1-Y_{h,w}^{(i)}) \log p(Y_{h,w}=0 \mid X^{(i)})$$

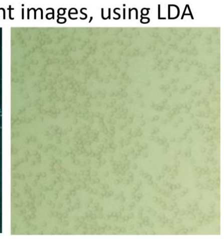
RESULTS – RED BLOOD CELL (RBC) SEGMENTATION

Hough Transform, used for automatic labeling, leads to many FN	Deep Learning without data augmentation, without pixel weights	Deep Learning with data augmentation, without pixel weights	Deep Learning with data augmentation, with pixel weights
			
Test IoU: NA	Test IoU: 0.65	Test IoU: 0.72	Test IoU: 0.70
Test Recall: NA	Test Recall: 0.40	Test Recall: 0.55	**Test Recall: 0.73**

APPLICATION – LEVERAGING OUR RED BLOOD CELL (RBC) SEGMENTATION TO DETECT MALARIA PARASITES

Goal: We classify “malaria parasites vs platelets”, in fluorescent images, using LDA

malaria vs platelet

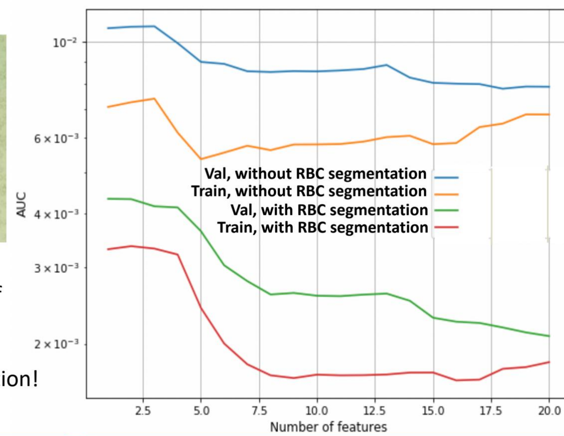


RBC segmentation

Hypothesis: Malaria classification improves if we add RBC segmentation as a feature

Result: Malaria classification improves by an order of magnitude using our RBC segmentation!

Test AUC=99.998% vs Test AUC=99.98%



DISCUSSION

- Automatic labels for RBC segmentation were initially very noisy. Data augmentation and pixel weights led to excellent RBC segmentation
- This is the first work to tackle automatic malaria diagnosis using low-resolution, cheap microscopes
- It paves the way to detecting malaria in areas with constrained access to medical infrastructure and medical expertise

FUTURE WORK

- Deploy the RBC segmentation & the malaria detection on portable chips
- Replace LDA classification with neural network classification

REFERENCES

[1] Ronneberger, et al. "U-net: Convolutional networks for biomedical image segmentation." ISBI 2015

[2] Huang, Gao, et al. "Densely connected convolutional networks." CVPR 2017